

Methods of Manufacturing Shoe Soles

Cross-Reference to Related Application

[0001] This application incorporates by reference, and claims priority to and the benefit of, German patent application serial number 10111229.7, which was filed on March 8, 2001.

Technical field

[0002] The present invention relates to a sole for an article of footwear, in particular a midsole with a support element for athletic shoes, wherein the midsole and the support element are made from a common polymer-based material and each exhibits a different mechanical property. Furthermore, the present invention relates to methods of manufacturing the sole.

Background

[0003] Conventional shoe soles typically have a three-layered structure consisting of an outsole, a midsole, and an inner sole. The outsole gives the shoe an outer ground-engaging profile that meets certain requirements for the specific activity for which the shoe is intended. Furthermore, the outsole may be made of a non-abrasive material to assure high wear resistance and a long working life of the sole. The midsole is often made of a foamed material, for example, elastomers with different densities. Because of the midsole's ability to deform resiliently, the midsole absorbs or dampens mechanical impacts that are generated during running and are transmitted to the body of a wearer via the shoe. The damping of these mechanical impacts can be supported by the integration of damping elements of different construction. Additionally, the midsole may be adapted to receive stability or support elements that are made of lightweight and

stable materials and support the foot during running. The support element supports the running motion of the wearer, because of its selective adjustable flexibility.

[0004] An example of support elements is described in U.S. Patent No. 6,199,303, which is hereby incorporated herein by reference in its entirety. The connection of the above-referenced parts of a sole, for example the midsole and the support element, can be achieved with various conventionally known methods. Conventional methods include stitching, sewing, and cementing or adhering. In a sole construction for athletic shoes, the different layers are typically connected by means of an adhesive, which has various disadvantages. For example, presently used adhesives often are volatile and harmful to the environment, because of the emission of certain gases. Additionally, known adhesives generally do not form a good bond between, for example, rubber and plastic sole elements, such that no durable connection is achieved and the elements can become detached from each other when in use. A further disadvantage is that the weight of the shoe is increased by the use of adhesives. Furthermore, the proper alignment of sole components to each other can be a difficult and expensive process. If the sole components are not optimally aligned, the shoe is uncomfortable to wear and does not perform as expected.

[0005] U.S. Patent No. 4,816,345, the disclosure of which is hereby incorporated herein by reference in its entirety, discloses connecting a rubber outsole and a foamed midsole. Both elements are connected by heating while contacting each other. As stated in the reference, this method does not involve a co-vulcanization process. The connection of thermoplastic polymers and rubber by co-vulcanization is disclosed in U.S. Patent No. 4,921,762, the disclosure of which is hereby incorporated herein by reference in its entirety. In the method disclosed in U.S. Patent No. 4,921,762, peroxidic vulcanization agents and vulcanization activators are added to the rubber. In this method, the respectively used plastic and rubber elements have to be

supplemented by chemical additives in a preliminary stage of the manufacturing process to later achieve a good connection. These additives are also bonding agents, which are expensive as basic materials. Additionally, costly machines are typically necessary to process the basic materials and the different additives. Because of the plurality of necessary method steps, the sole manufacturing process is expensive and time-consuming.

[0006] It is, therefore, an object of the present invention to provide a method for manufacturing and connecting sole elements that is less time-consuming and less expensive compared to conventionally known methods. It is a further object of the present invention to provide a low-cost sole that comprises additional support elements in the midsole and to provide a shoe with such a sole.

Summary of the Invention

[0007] The present invention relates to a low-cost method of manufacturing a sole element, particularly for athletic shoes. The shoe sole of the present invention overcomes the disadvantages of known methods for producing shoe soles, because the components of the sole are made from a common polymer-based material and the components are attached to each other without using additional materials, thereby reducing the materials and procedural steps necessary to produce the sole. Generally, the components of the sole originate as preforms manufactured by pre-vulcanization, wherein cross-linking agents contained in the preforms are not completely vulcanized. Subsequently, the components of the sole are co-vulcanized in a mold.

[0008] In one aspect, the invention relates to a method of manufacturing a portion of a sole of an article of footwear. The method includes the steps of providing a sole element and a support element having a common polymer-based material, positioning the sole element and the support element in a mold, and applying at least one of heat and pressure to the mold, thereby attaching

the sole element with the support element. The sole element and the support element individually exhibit a different mechanical property.

[0009] In another aspect, the invention relates to a sole for an article of footwear. The sole includes a sole element and at least one support element. The sole element and the support element are manufactured from a common polymer-based material, each exhibiting a different mechanical property. The sole element and the at least one support element are attached by co-vulcanization.

[0010] In yet another aspect, the invention relates to an article of footwear including an outsole, an inner sole, an upper, and a midsole including a support element. The midsole and the support element are manufactured from a common polymer-based material, each exhibiting a different mechanical property. The midsole and the support element are attached by co-vulcanization.

[0011] In various embodiments of the foregoing aspects of the invention, the sole element (or midsole) may be manufactured from ethylene vinyl acetate ("EVA"). The support element can also be manufactured from EVA. In one embodiment, the support element includes a vinyl acetate content of about 18% to about 25%, at least one peroxide, and a co-agent. The co-agent may be an acrylate or an isocyanate. In one embodiment, the sole element includes a vinyl acetate content of about 18% to about 27%. The sole element may also include a filler, at least one peroxide, and a blowing agent for foaming the sole element in the mold.

[0012] Furthermore, the different mechanical properties that the sole element and the support element exhibit can be hardness, stiffness, resiliency, or compliancy. In one embodiment, the sole element, the support element, or both are formed from a partially vulcanized preform. The sole element and the support element can be applied to each other and co-vulcanized to

permanently attach them. The support element can have a hardness of about Shore A 80 to 95 to a hardness in the Shore D range.

[0013] These and other objects, along with advantages and features of the present invention herein disclosed, will become apparent through reference to the following description, the accompanying drawings, and the claims. Furthermore, it is to be understood that the features of the various embodiments described herein are not mutually exclusive and can exist in various combinations and permutations.

Brief Description of the Drawings

[0014] The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the present invention are described with reference to the following drawings, in which:

FIG. 1 is a schematic partial cross-sectional view of an article of footwear;

FIG. 2 is a schematic top view of a portion of a sole in accordance with the invention;

FIG. 3 is a flow chart illustrating the various steps of a method of producing a sole in accordance with the invention; and

FIG. 4 is a flow chart illustrating the various steps of another method of producing a sole in accordance with the invention.

Detailed Description of the Invention

[0015] Embodiments of the present invention are described below. It is, however, expressly noted that the present invention is not limited to these embodiments, but rather the intention is that modifications that are apparent to the person skilled in the art are also included. In particular, the present invention is not intended to be limited to soles for sports shoes, but rather it is to be understood that the present invention can also be used to produce soles for any article

of footwear. Also, the methods disclosed herein can be applied to other items of manufacture besides footwear. Further, only a left or right sole and/or shoe is depicted in any given figure; however, it is to be understood that the left and right soles/shoes are typically mirror images of each other and the description applies to both left and right soles/shoes.

[0016] As shown in FIG. 1, a sole 14 of an article of footwear 10 includes an outsole 16, a midsole 18, and an inner sole 20. The midsole 18 may be supplemented by one or more additional structural support elements to provide a structural frame, since the midsole 18 is typically made of damping foam.

[0017] FIG. 2 depicts a sole 22 in accordance with the invention. The sole 22 could be an outsole, a midsole, or an inner sole. The sole 22 shown is a midsole, including a sole element 24 and a support element 26. The support element 26 can be essentially any size or shape, and the sole 22 can include a plurality of support elements 26. The size, shape, and number of support elements 26 are chosen to suit a particular application.

[0018] The sole 22 can be made of EVA. Typically, EVA is based on a vinyl-acetate (VA) content of about 18% to about 25%. EVA can include fillers, for example, silicon-dioxide (SiO_2) or titanium-dioxide (TiO_2), as well as cross-linking agents and processing promoters. Cross-linking agents include, for example, peroxides. Additionally, co-agents can be added to the material to harden the material during vulcanization. Such co-agents include, for example, acrylates and isocyanates. If the EVA is to be foamed, a blowing agent can also be added to the initial material mixture.

[0019] Support elements are typically made of plastics having high mechanical stability as compared to the properties of the midsole materials. Typical support elements are made from thermoplastic polyether block amides, such as the Pebax[®] brand sold by Elf Atochem, or

thermoplastic polyurethane (TPU). In contrast thereto, support elements 26 in accordance with the invention are made of the same common polymer-based material as that of the sole element 24, in this case EVA, but have different mechanical properties than the common polymer-based material of the sole element 24. The different mechanical properties are at least in part determined by the degree of cross-linking of the contained macromolecular substances.

[0020] FIG. 3 is a flow chart illustrating the various steps of a method in accordance with the invention. The method includes the step of providing a sole element and a support element 32, positioning the sole element and support element within a mold 34, and an attachment step 36, all of which are described in greater detail hereinbelow.

[0021] FIG. 4 is a flow chart illustrating the various steps of another method in accordance with the invention. The method includes one or more manufacturing steps 42, 44 for producing a sole element preform and a support element preform, a positioning step 46 for positioning the sole element preform and support element preform within a mold, and a co-vulcanization step 48, all of which are also described in greater detail hereinbelow.

[0022] The sole element 24 and the support element(s) 26 are typically initially manufactured as separate preforms. The independent manufacture of the preforms allows for the adjustment and tailoring of the different mechanical properties of the final processed sole element 24 and support element 26. The manufacture of the preforms of the support element 26 and the sole element 24 is carried out based on a common polymer-based material, such as EVA. The support element 26 and the sole element 24 are similar in view of their polymer-basis, but do not have corresponding final structure or performance characteristics.

[0023] The material mixture of the sole element preform and the support element preform can be supplemented by the addition of blowing agents, peroxides, and fillers, as desired. Examples of

peroxides and fillers include, for example, di-comyl-peroxide as a peroxide and silicic acid as a filler. The added peroxides serve for cross-linking the polymer-based material. It follows therefrom that the preforms of the sole element 24 and the support element 26 can differ in their mechanical properties. Starting from the same polymer-based material, for example EVA, the preforms of the sole element 24 and the support element 26 are manufactured in different ways in order to adjust differently the mechanical properties of each. This production is carried out by pre-vulcanization.

[0024] In one embodiment, the sole element 24 includes EVA having a vinyl acetate content of about 5% to about 35%, preferably about 15% to about 30%, and more preferably about 18% to about 27%. The sole element 24 further includes the above-mentioned filler(s) and peroxide(s). In addition, a blowing agent can be added, so that the sole element preform can be shaped later in a mold as a finished foam. The above composition is pre-vulcanized for adjustment of the mechanical properties of the sole element preform and for the provision of the initial shape thereof. The pre-vulcanization step is typically carried out at temperatures of about 155 °C to about 170 °C. Compared to conventional vulcanization, pre-vulcanization requires a shortened time-period. The pre-vulcanization causes a certain limited degree of cross-linking in the EVA, whereby the mechanical properties of the sole element preform are adjusted or controlled.

[0025] In one embodiment, the support element 26 includes EVA having a vinyl acetate content of about 5% to about 35%, preferably about 15% to about 30%, and more preferably about 18% to about 25%. Peroxides and fillers are added, as discussed hereinabove. Additionally, co-agents can be added to the material mixture for hardening the material during vulcanization. Acrylates or isocyanates are examples of such co-agents. In comparison to the material of the sole element preform, typically no blowing agent is added to the material mixture so that the

support element 26 is finished as a solid, not a foam. The above composition is pre-vulcanized for adjustment of the mechanical properties of the support element preform and for the provision of the shape. The pre-vulcanization is usually carried out at temperatures of about 155 °C to about 170 °C. In comparison to the sole element preform, a higher degree of cross-linking is obtained to achieve certain mechanical properties. These mechanical properties can include, for example, a greater stiffness and hardness, as compared to the sole element preform. For example, the support element preforms can have a hardness of about Shore A 80-95 or greater. By adding further additives, for example, di- or trimodal acrylate, it is possible to produce a support element 26 having a hardness in the range of Shore D. In this context, the Shore hardness is determined according to ISO-standard 868-1985 or DIN-standard 53505. With respect to the difference between the mechanical properties of the sole element 24 and the support element 26, this difference can be quantified as a different value or degree of the same property. For example, the sole element 24 can have a certain value of hardness, while the support element 26 can have a different, greater value of hardness. In one embodiment, the mechanical properties of the support element 26 correspond to the hardness values of Pebax® and TPU, which are typically used for the manufacture of known support elements; however, these materials are expensive and cannot be processed optimally with respect to their outer appearance and incorporation in a sole.

[0026] The support element preforms are pre-vulcanized and subsequently cut into one or more pieces of the appropriate shape. The preform shape can vary according to the function of the support element 26. For example, elongated structures or V-shaped structures, whose configuration support the flexibility of the sole 22, are possible. Furthermore, support elements 26 having a comparatively large surface area or volume can also be produced and positioned

adjacent a medial or a lateral side of the sole 22 to correctively support defects or malformations in the bone structure of a wearer's foot.

[0027] The aesthetic design of the preforms can be modified after manufacture by means of silk screen printing. For example, because of the smooth surface quality of the support element preforms made from EVA, it is possible to fashion the preforms, as desired, without great expense by means of a silk screen printing process. In so doing, it is possible to adapt the colored surface design of these portions of the sole 22 to the upper and/or the whole sole of the later produced shoe. In contrast thereto, films or foils used for fashioning TPU elements are relatively complicated to apply and expensive with respect to their manufacture.

[0028] After the preforms of the support element 26 and the sole element 24 have been produced from the common polymer-based material, they are arranged in a mold having a cavity that determines the final sole shape. In this process, the support element preform can be positioned on a lower side of the mold and the sole element preform arranged above the support element preform. After closing the mold, heat and/or pressure is applied to the preforms within the mold. The heat and/or pressure causes further shaping and attachment of the sole element preform and the support element preform, as well as a hardening of the support element preform. Generally, this process of attachment can be referred to as co-vulcanization, where a cross-linking between the common polymer-based material of the sole element preform and the support element preform occurs. The co-vulcanization is performed at temperatures of about 155 °C to about 170 °C. The connection between the sole element 24 and the support element 26 results from the peroxides in the materials. These peroxides are not completely vulcanized during the step of pre-vulcanization during the manufacture of the sole element preform and the support element preform. The peroxides are cross-linking agents that principally enable the vulcanization of the

polymer-based material. Therefore, the sole element 24 and the support element 26 are attached to each other without additional material or steps, for example, adhesives, reactive functional groups being added to the polymer-based material, or mechanical fastening.

[0029] In an embodiment where the sole element 24 is to be foamed, after closing the mold, the above-mentioned blowing agent contained in the sole element preform is activated by the heat and/or pressure applied to the mold. The sole element preform is foamed and thereby enlarges its volume, being pressed into the predetermined shape of the mold cavity and a sole element 24 is formed. At the same time, the sole element preform and the support element preform are permanently attached to each other. Furthermore, the support element preform is hardened during this process without substantially changing its shape and finally forms a support element 26. A substantial advantage of this process is that a permanent connection between the sole element 24 and the support element 26 is provided without adding other materials to the basic material of the sole element preform, the support element preform, or both. Thus, a sole 22 including a sole element 24 and a support element 26 is produced in accordance with the invention, where the preforms are made entirely of the common polymer-based material and the support element 26 is attached to the sole element 24 only by the application of pressure and/or heat. After the manufacture of the sole 22, for example a midsole, an outsole, an inner sole, and an upper can be connected to the midsole by conventional methods, such that a shoe in accordance with the invention is produced

[0030] The above-described manufacturing process has substantial advantages over known methods. For example, it is not necessary to attach the support element 26 and the sole element 24 with an adhesive. Eliminating the use of adhesives is of increasing importance in reducing environmental impact. Also, using an adhesive can lead to the sole losing flexibility due to the

curing of the adhesive. Further, a separate step of shaping the midsole to have an exact fit to the support element 26 is eliminated. The exact fit of the support element 26 in the sole element 24 follows from the method according to the invention. In addition, misalignment of the sole element 24 and the support element 26 during cementing in place is prevented. The additional procedural steps required to position a support element in a sole element and apply an adhesive are also eliminated. Further, only one mold is necessary in the method according to the invention, because the sole element 24 is shaped and attached to the support element 26 at the same time. The manufacture of the sole 22 and the whole shoe in accordance with the invention is reduced in terms of expense, production time, and the number of procedural steps required, thereby resulting in a simpler, less expensive, and environmentally friendlier shoe. An additional cost reduction can be realized from the use of EVA as the support element 26, because previously used materials are comparatively expensive, for example, TPU or Pebax®.

[0031] In addition to the advantages outlined above, a substantial advantage also results with respect to the comfort of the shoe manufactured in accordance with the invention. By using EVA for the manufacture of the preforms of the sole element 24 and the support element 26, the mechanical properties of the sole element 24 and the support element 26 can be adjusted as desired. In contrast thereto, support elements made of Pebax® or TPU are relatively stiff and inflexible and their mechanical properties are not variable. With respect to children's shoes, a lower force is available for deforming of the sole, because of the low weight of children. Thus, it is advantageous in this case to produce a sole with a high degree of flexibility resulting from a suitable material adjustment.

[0032] Having described certain embodiments of the invention, it will be apparent to those of ordinary skill in the art that other embodiments incorporating the concepts disclosed herein may

be used without departing from the spirit and scope of the invention. The described embodiments are to be considered in all respects as only illustrative and not restrictive. For example, materials other than EVA can be used as the common polymer-based material, such as polyurethane, thermal plastic elastomer, polystyrene, polyvinyl chloride, phenolic, and polyolefin.

[0033] What is claimed is: